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Methodological Approach to Determination of Priorities in Ecological Estimation of the Russian Territories

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Abstract

This paper assesses the main types of environmental impact caused by mineral exploration and mining. The ecological situation due to the extraction and processing of mineral raw materials in the mining regions, as well as the environmental impact of accumulated mining waste are shown. The results of environmental monitoring of the quality of the industrial urban environments of the Russian Federation are also presented. Based on the analysis of the database of existing man-made formations, including those produced from the rare metal deposits, the maps of their distribution over the territory of Russia as a whole and the territory of the Ural Federal District are compiled. The ranking of man-made deposits and formations by their impact on environmental elements has been performed.

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Studying and forecasting the impact of natural and technogenic factors on the environment associated with the exploration and development of mineral deposits has been carried out for many years, both at the local and regional levels, in order to reduce, and in some cases, prevent the negative consequences of the planned activity on natural objects, i.e., atmospheric air, water resources, soil, flora and fauna.

The main environmental impacts are: land acquisition for the location of the main and auxiliary production; pollution of vegetation and soil as a result of atmospheric impacts and deposition of harmful substances on vegetation and soil cover [1].

Environmental monitoring should be carried out at all stages, from geological exploration to the ore deposit development, during the liquidation of mining and reclamation of disturbed lands, after completion of reclamation and until the complete stabilization of the territory. Environmental geochemical studies (identification of areas of pollution of environmental components by toxic substances, assessment of the degree and composition of their pollution; assessment of potential geochemical endemicity; zoning of the territory according to the level of pollution and the degree of environmental hazard. identification of sources of pollution; identification of areas of potential industrial

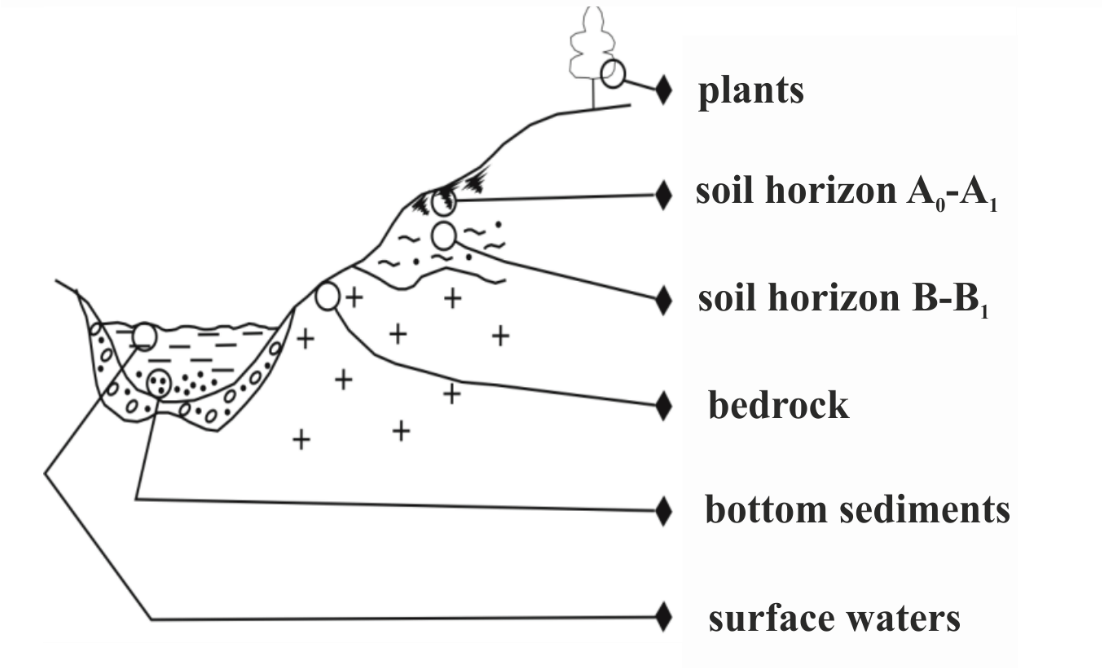

Figure 1: A system of conjugated components of the geological environment.

objects; ecological and geochemical monitoring and forecast of the development of negative processes; development of recommendations for the rehabilitation of areas of unfavorable environmental conditions; identification of populations with an increased morbidity risk) make the basis of this work.

During the development of mineral deposits and related economic activities, the technogenic pollution and changes in the natural landscapes occur, the soil cover becomes inevitably disturbed due to site planification and infrastructural preparations for the production facilities disposal. The development and processing of ores by any of the methods entails chemical pollution of the natural environment, including the hydrosphere, as a result of oxidation, grinding, transport of ores and host rocks, use of flotation reagents for enrichment, etc.

Mining industry accounts for ca. 70-80% of the volume of all man-made formations, which features are individual due to variations in the feed stock composition, the processing flow chart, and a number of other factors. Practice of environmental geochemical studies demonstrates that the hardest environmental and geochemical impacts are associated with the functioning of large industrial units.

The distribution of recorded man-made formations (a total of 576 objects) in the Russian Federation was analyzed by the following features: areal extent, type of storage, type of technogenic formations, the hazard classes, and the environmental impact level [3].The man-made formations were ranked on the basis of available data. Of particular concern was the processing plant waste, since its storage requires special engineering structures, and the waste itself contains harmful chemical elements and compounds. Quantitatively these are well below than the overburden and host rocks; however they affect the environmental situation more intensely. For example, the environmental situation caused by the extraction of mineral raw materials and waste disposal by more than 25% of the territory of the Ural Economic Region is estimated as a crisis. The areal extent of such lands is a bit smaller in the south of the Russian Far East, the Khanty-Mansi Autonomous District, the Tyumen Region, the Krasnoyarsk Territory, and other areas of intense oil and gas production, mining and processing of minerals.

The industrial productive facilities make one of the sources of both marketable products and environmental hazards. Therefore, an objective assessment and detailed exploration of each promising man-made deposit are needed. However, the estimates have been carried out so far at a few sites.

Within an urbanized territory with numerous production facilities, the influence zones of various pollution sources overlap, thus creating a sophisticated pattern of the technogenic substances distribution. All types of industrial dust are rich in various chemical elements, and their concentration levels vary widely, depending on the materials used and the technological process employed; often their content in the landscape components exceeds the natural background by several decimal orders. The geochemical sampling data from the territories adjoining the industrial enterprises demonstrated the presence of widespread heavy metal pollution of the soil cover and atmospheric air displayed as the technogenic geochemical anomalies in the environmental components (in this case, in the snow cover, in the dust layer accumulated during the summer season, and in the soil).

Emissions of enterprises with high and very high content levels of chemical elements cause the greatest environmental impact, even if the amount of dust emitted is relatively small.

Further we present the results of monitoring of the environment quality of the Russian industrial cities. One of the ways to express the monitoring results is to calculate several complex indicators characterizing the quality of a given natural environment (air, water, soil, etc.). To calculate these indicators, the data observed are normalized by relevant regulated values. In most natural environments, such as the atmosphere, surface and underground hydrospheres, the maximum permissible concentration (MPC) of a chemical substance acts as the normalizing value. By the overall estimate of the ecological state, the Russian cities fall into the five categories: 1 - safe, 2 - satisfactory, 3 - moderately intense, 4 - intense, 5 - critical. Seven cities of the Russian Federation are assigned to the 1st category, 26% to the 4th, and 9% to the 5th. To assess the degree of chemical pollution of soils in Russia, the following three indicators are usable: Zп (the MPC-normalized observed values, Zф (background-normalized), and Zк (crustal abundance-normalized). The weighted average total contents of heavy metals (the hazard classes 1 and 2) were studied: Pb, Cd, Hg, Zn, Ni, and Cu. The data sources were the open file technical monitoring reports for the period 2006-2014. Using the three above mentioned assessment criteria, Irkutsk, Penza, Saratov, Chelyabinsk, Yekaterinburg fell into the 1st (highly dangerous) category, Perm and St. Petersburg made the list of the 2nd (dangerous), whereas Blagoveshchensk and Vologda made the 3rd (moderately dangerous) category [2].

The analysis of the most intense technogenic environmental impacts revealed the following controls responsible for deterioration of the environmental situation in the territories: zones of intensive development of the metallurgical, energy, and chemical industries, characterized by the high pollution level of the environmental components, as well as severe consequences in case of emergency situations; the hydrocarbon production and refinery regions characterized by dramatic (sometimes irreversible) changes in the natural landscapes, which compose extremely unstable ecosystems and display a high level of the production accident rate; highly populated and densely developed urban areas with a thick transport network, developed housing and communal complex; areas of intensive agricultural development.

When estimating the results of ecological and geochemical studies, it should be borne in mind that not only the abnormally high content of chemical elements in the environmental components can pose an environmental hazard. A deficiency of vital elements can pose a significantly greater threat to human health than traditionally understood pollution.

The toxicity of mining products depends on their physical condition and chemical composition. Understanding the mechanisms of the impact of chemical elements and compounds on the environment and public health enables mitigation of related sanitary problems and to carry out acceptable mining and processing of the mineral raw materials. In this case, it is necessary to take into account the whole range of sources and objects of influence in order to create a system of medical and environmental safety measures within the territories studied.

Finally, it should be emphasized that the environmental consequences of accumulated mining waste are more grave than what is stated in various materials, one way or another relating to the problem under consideration, and are global in nature. The extent of the loss of land, water, forest, recreational and other resources due to subsoil use in general and from unused waste in particular put these processes on a par with negative factors that threaten the country’s security.

References

[1] Aleksandrova, T. N. and Nikolaeva, N. V. (2015). Ecological Geochemical Estimation of the Mining Waste in Russia. St. Petersburg: Politechnical University Publishers.

[2] Pomelyaiko, I. S. (2017). Ecological and Geochemical Ranking of Residential Areas of a Number of Resorts and Industrial Cities of the Russian Federation Using Three Soil Pollution Indicators. *Geoekologiya*, issue 1, pp. 28-39.

[3] Spiridonov, I. G. and Levchenko, E. N. (2018). Mining Waste vs. Ecological Safety. *Prospect & Protection of mineral resources*, issue10, pp. 15-24.